ONR Chair in Arctic Marine Science

Robert H. Bourke
Department of Oceanography
Naval Postgraduate School
833 Dyer Road, Bldg. 232, Rm. 328
Monterey, CA 93943-5122
Voice: (831) 656-2962 fax: (831) 656-2712 email: bourke@oc.nps.navy.mil

Ursula Schauer
Alfred Wegener Institute for Polar and Marine Research
Postfach 120161
D-27515 Bremerhaven, Germany
Voice: 471-4831-1817 fax: 471-4831 1797 email: uschauer@awi-bremerhaven.de

Award #: N0001401WR20110 (Bourke) N000140110049(Schauer)
http://www.onr.navy.mil/sci_tech/ocean/onrpgahl.htm

LONG-TERM GOAL

A research Chair in Arctic Marine Science was established in 1976 by the Chief of Naval Research to increase the awareness of naval operational concerns among national and international polar scientists across a broad spectrum of disciplines. The Chair has been continuously occupied for 24 years by visiting scientists in residence at NPS for one year each.

OBJECTIVES

To foster oceanographic research in the Arctic, acquaint naval officer students and other students with Arctic problems, reduce results of pure research to operational usage and publicize Navy interest in the Arctic region.

APPROACH

Annually the PI conducts a national/international search for candidates for the Chair. Solicitations are made by letter to potential candidates, to institutions having a polar interest and by advertisements in EOS and electronic bulletin boards. Candidates are selected based on their reputation, scholarly contributions to polar science and their science specialty to ensure broad representation from the observational and modeling communities. Typical candidates are those with specialties in remote sensing, ice physics, underwater acoustics, chemical oceanography, climate dynamics as well as the more traditional physical oceanographer or atmospheric scientist.

WORK COMPLETED

Chair recruitment proceeded as described above. Dr. Ursula Schauer of the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany was selected as the incumbent for FY 01.

RESULTS

Fluxes of Atlantic Water to the Arctic Ocean and its modification along the two pathways were investigated based on measurements carried out in European programs in the 1990s in Fram Strait, in the Barents Sea and the St. Anna Trough.

The Atlantic Water branch through the Barents Sea varies seasonally between 0.6 Sv in summer and 2.6 Sv in winter. A weak flow (0.3 Sv) of warm Atlantic Water enters from the Arctic Ocean through the St. Anna Trough towards the Barents Sea. This water originates in the Fram Strait branch of Atlantic water north of the Barents Sea. The eastward flowing AtlW is considerably modified in the central Barents Sea. It is cooled and densified through brine enrichment from sea ice formation. The ice formation, however, takes place in areas of low surface salinity so that the locally resulting dense plumes have a lower salinity than the Atlantic Water. While passing the Barents Sea, the dense plumes entrain Atlantic Water thus forming a persistent deep flow with temperatures well above the freezing point (Fig. 1). About 70% of the total eastward flow in the 1990s was colder than 0°C and thus will not be referred to as Atlantic Water in the Arctic Ocean. Obviously, the Barents Sea branch of AtlW did not contribute significantly, if at all, to the warming of the intermediate layers in the Arctic Ocean.

The dense plume water is generated in the polynyas west of Novaya Zemlya, and possibly also at the Central Bank. The incorporated fresh surface water west of Novaya Zemlya, which despite brine involvement induces the relatively low salinity in the plumes, stems primarily from continental runoff and above the Central Bank from ice melt. The amount of fresh water in the eastward flow is about 20% of the terrestrial fresh water supply to the western Barents Sea. Hence the amount and distribution of continental runoff plays a crucial role in how deep the Arctic Ocean will be ventilated by Barents Sea Water. Barents Sea water enters the Nansen Basin with a cold low salinity signal at or below the core depth of the warm saline Fram Strait branch of Atlantic Water, and, at least in the 1990s, its low salinity prevented it from penetrating the Arctic Ocean below 2000 m.

In the 1960s, i.e. during the “cold cyclonic cycle” of Arctic climate (Proshutinsky et al., 1999), the Atlantic Water, advected from Fram Strait, was colder by almost 2K as compared to the 1990s. The dense Barents Sea water in the St. Anna Trough was colder by 1K only in a very thin layer at the bottom, and it had about the same salinities as in the 1990s. We conclude that the variability of the Barents Sea Water outflow is less than that of the Fram Strait branch of Atlantic Water.

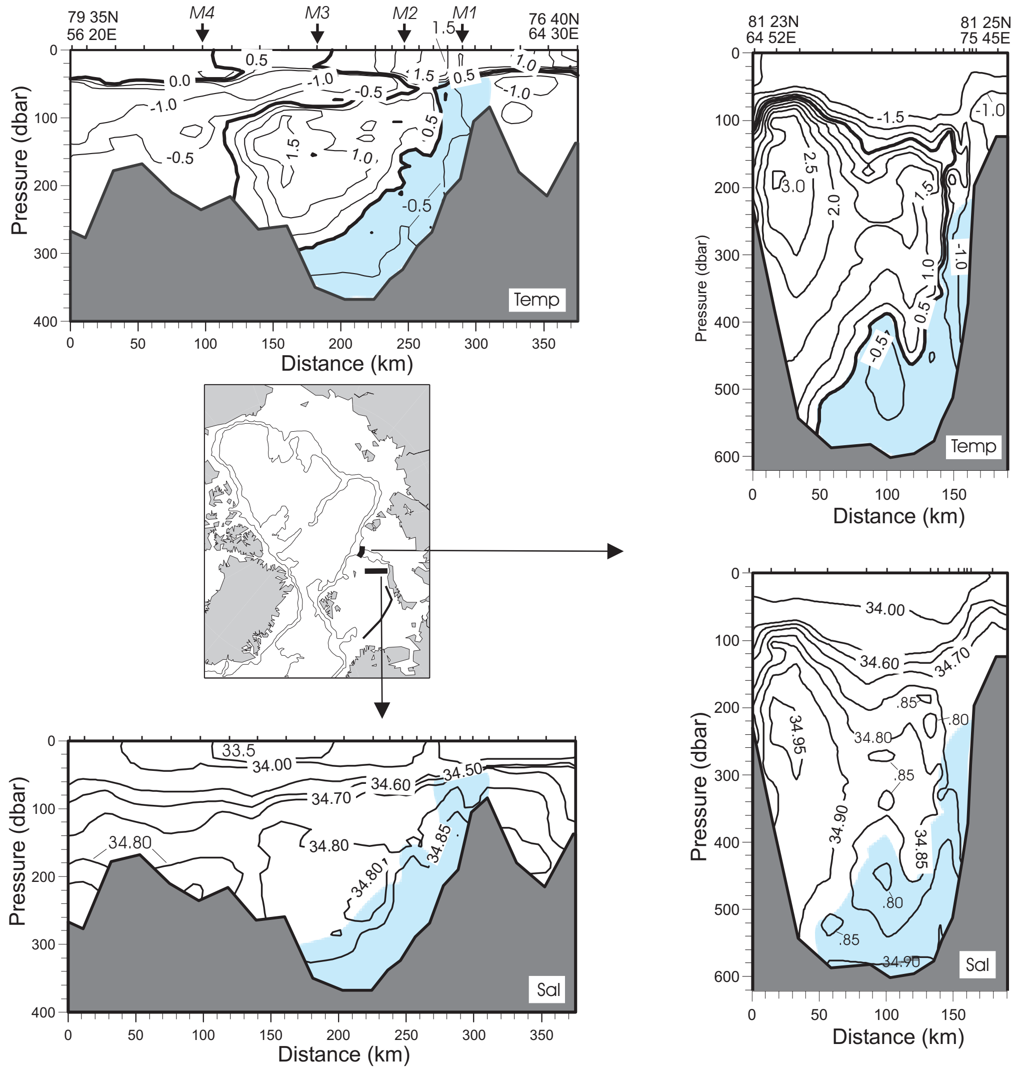

Figure 1: Temperature and salinity in the Barents Sea

[Figure 1: Distribution of temperature and salinity in the northeastern Barents Sea (left panel) and in the St. Anna Trough (right panel). Shaded areas indicate the plume of cold low salinity modified Atlantic Water which flows northeastward from the Barents Sea to the St. Anna Trough where it enters the Arctic Ocean deep basins.]

Three years of high resolution mooring data across Fram Strait permit detailed estimates of volume and heat flow. Full depth volume fluxes are on the order of 10 Sv both northwards and southwards with only small southward net flow (order 3 Sv). The temperature of the West Spitsbergen Current has a strong seasonality with a minimum in winter due to cooling of the Atlantic Water in the Nordic Seas. Nevertheless, the northward heat flow is highest in winter caused by the winter maximum northward volume transport (Fig. 2).

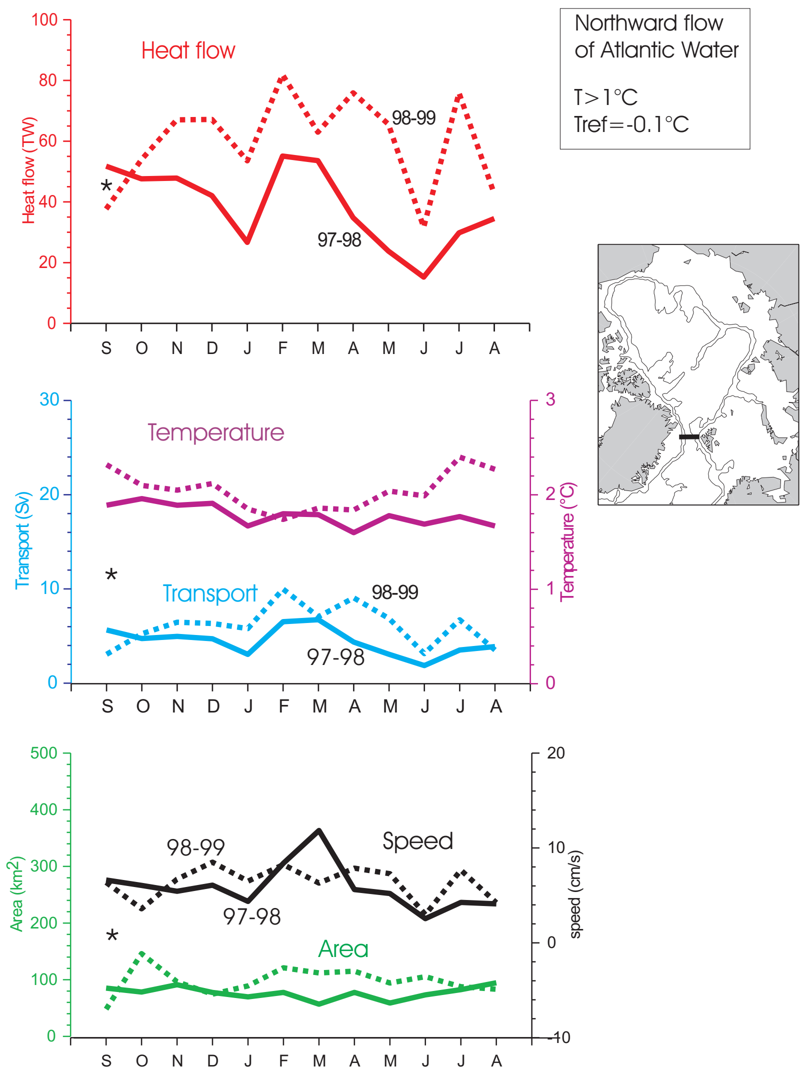

Figure 2: Monthly mean values in Fram Strait

[Figure 2: Monthly mean values of Atlantic layer heat flow towards the Arctic Ocean through Fram Strait from two years, and monthly values of the area averaged constituents of heat flow. The heat flow was largest in winter in both years when the temperature was at its minimum but when the transport was highest.]

Between 1997 and 2000, the heat flow in the West Spitsbergen Current (WSC) increased from 30 to 50 TW as a result of both increased speed and temperature. Most of the increase took place in off-shore branches of the WSC and the heat flow increase in the branch crossing the Yermak Plateau to enter the Eurasian Basin was small. In contrast to the WSC, during these three years the volume and heat transport of East Greenland Current remained fairly constant and an integration over a subsection showed identical values of volume transport to that obtained by measurements in the 1980s. The yearly total net heat transport across 79°N was between 20 and 45 TW in the late 1990s that, according to long-term hydrographic observations, represents a phase of moderately warm Fram Strait conditions. An increase in heat flow through Fram Strait as observed in the late 1990s would be sufficient to explain the warming in the upper Arctic Ocean earlier in that decade.

IMPACT/APPLICATIONS

By spending a year at NPS, Dr. Schauer has become more aware of Navy needs and operational requirements, factors that will carry over in future years. Specifically, her research on the fluxes of Atlantic Water into the Arctic Ocean and its modification enroute should assist both observationalists and modelers in their interpretation of the response of the Arctic ocean to climate change. The role of the Barents Sea and the St. Anna Trough in water mass transport and modification has bee elucidated with modern data, updating our views based on data acquired nearly fifty years ago.

TRANSITIONS

The work described above represents an analysis of two unique and valuable data sets that will be used by climate researchers studying the role of the Arctic for the European climate. It will have particular relevance to the European ASOF (Arctic-Subarctic Ocean Flux Array) program designed to study fluxes between the Arctic and Atlantic Oceans.

RELATED PROJECTS

SEARCH and SBI

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